CHAPTER 5: CONTAMINANT CONSIDERATIONS IN THE FLOW RECOMMENDATION PROCESS

Contaminants were identified as a potential issue of concern for the native fishes in the San Juan River when the SJRIP was initiated. Both natural (selenium) and manmade (polycyclic aromatic hydrocarbons (PAHs)) contaminants were identified for study during the 7-year research period. Several studies were conducted that investigated contaminant levels in the river, as well as potential sources and effects of contaminants on the native fishes (Abell and Wilson 1994; Wilson et al. 1995; Hamilton and Buhl 1995, 1996; Odell 1995, 1997). This chapter reviews the results of these contaminant studies and discusses how those results were used in the flow recommendation process.

HISTORICAL CONDITIONS

The available data on concentrations of selected dissolved trace elements such as arsenic (As), copper (Cu), selenium (Se), and zinc (Zn) in the reaches of the San Juan, Animas, La Plata, and Mancos rivers were compiled from the Environmental Protection Agency's (EPA's) STORET database. The database was searched for samples collected at any gaging station on the San Juan River between the Archuleta, New Mexico, and Bluff, Utah, gaging stations. The data sources consisted of the STORET database compiled by the EPA and the USGS through 1994 and data collected by the Farmington New Mexico BIA during the San Juan Study from 1991 to 1997.

The data sources contain analyses performed using various methods; hence, there are many different detection limits for each element. For example, the detection limits ranged from 0.5 parts per billion (ppb) to 100 ppb for As, 1 to 10 ppb for Cu, and 2 to 50 ppb for Zn. In order to include these measurements below their detection limit, the detection limit for As, Cu, and Zn was multiplied by 0.5, and for Se it was multiplied by 0.6. The corrected detection limit values were then treated as measured concentrations in the statistical analysis for each element.

For each reach of the San Juan River, there was no statistically significant difference in the mean concentrations of these trace elements. The variances in the measurements are so large that no trends in the mean concentrations could be determined (i.e., by least squares the coefficient of determination was less than 10%). The only way to observe a trend was to calculate the mean values at various sites along the river. After this calculation, there was still no trend in the means for As and Zn. From Archuleta to Bluff, Se showed an increase from 0.7 to 1.3 ppb (the detection limit is 1 ppb). The mean Cu concentration went from 4 to 5 ppb (the detection limit for Cu is 2 to 5 ppb). For the dissolved trace elements in water (As, Cu, Se, and Zn) there was not a statistically significant

change in concentrations as the flow decreased. Allowable samples were constrained to those collected only within the lower reaches of the river (Shiprock, New Mexico, to Mexican Hat, Utah). At flows below 500 cfs, no changes were detected. Linear regression of concentrations versus flows has $r^2 < 0.05$ for each element. If a trend between these contaminants and flow existed, it was small and masked by variation in measured levels of the elements.

Using the same analysis of looking for trends in the mean values provided additional information (Table 5.1). The analysis was initially carried out using all measurements along the mainstem. It was then restricted step by step, going only to stations from Shiprock to Bluff. Analysis was then carried out for flow conditions of less 1,500 cfs and, finally, for flows less than 500 cfs. The extreme concentration was also used to show the highest concentration observed under the low flow condition (Table 5.1). This was an attempt to include a seasonal high concentration not reflected in the mean value. No trends were seen in these data to suggest a relationship between contaminant concentration and flow.

Table 5-1. Mean concentrations of selected trace elements under various constraints.

CONSTRAINTS	MEAN CONCENTRATION AS PPB (NO. OF SAMPLES) [STD. DEV.]			
	Arsenic (As)	Copper (Cu)	Selenium (Se)	Zinc (Zn)
Archuleta-Bluff	2 (1298)[3]	4 (435)[3]	0.9 (1175)[0.6]	19 (1300)[60]
Shiprock-Bluff	2 (683)[3]	5 (293)[3]	1.0 (619)[0.7]	21 (681)[41]
Shiprock-Bluff < 1,500 cfs	2 (377)[4]	5 (128)[3]	1.0 (311)[0.8]	18 (372)[32]
Shiprock-Bluff < 500 cfs	2 (45)[1]	5 (10)[2]	1.1 (41)[0.6]	14 (46)[40]
CONSTRAINTS	**EXTREME CONCENTRATION AS PPB (YEAR OF OCCURRENCE)**			
	As	**Cu**	**Se**	**Zn**
Shiprock-Bluff < 500 cfs	3 31 scattered days	10 (7-6-72)	2 (4-7-81,7-18-89 8-30-93,4-24-96)	270 (8-21-92)

During the 7-year study, various biological samples (fishes, macroinvertebrates, and periphyton) were collected from the San Juan River. These samples were analyzed for up to 32 trace elements including As, Cu, Se, and Zn. Fish bile samples and semi-permeable membrane device (SPMD) samples have also been collected for analysis of PAHs at various sites along the San Juan River and its tributaries.

The trace element concentrations in organisms are highly variable depending on species and environmental conditions. In any single species, there are some differences in trace element or PAH concentrations that depend on location. Most trace elements showed no concentration differences in organisms as a function of location. The variation was large, and too few samples were collected to detect any systematic differences. The concentration differences in PAHs were usually abrupt, indicating some local cause for the difference. For Se, the highest concentrations occurred in organisms collected near Blanco, New Mexico (RM 205), and concentrations gradually decreased downstream and did not change below Shiprock (RM 150), as shown in Figure 5.1.

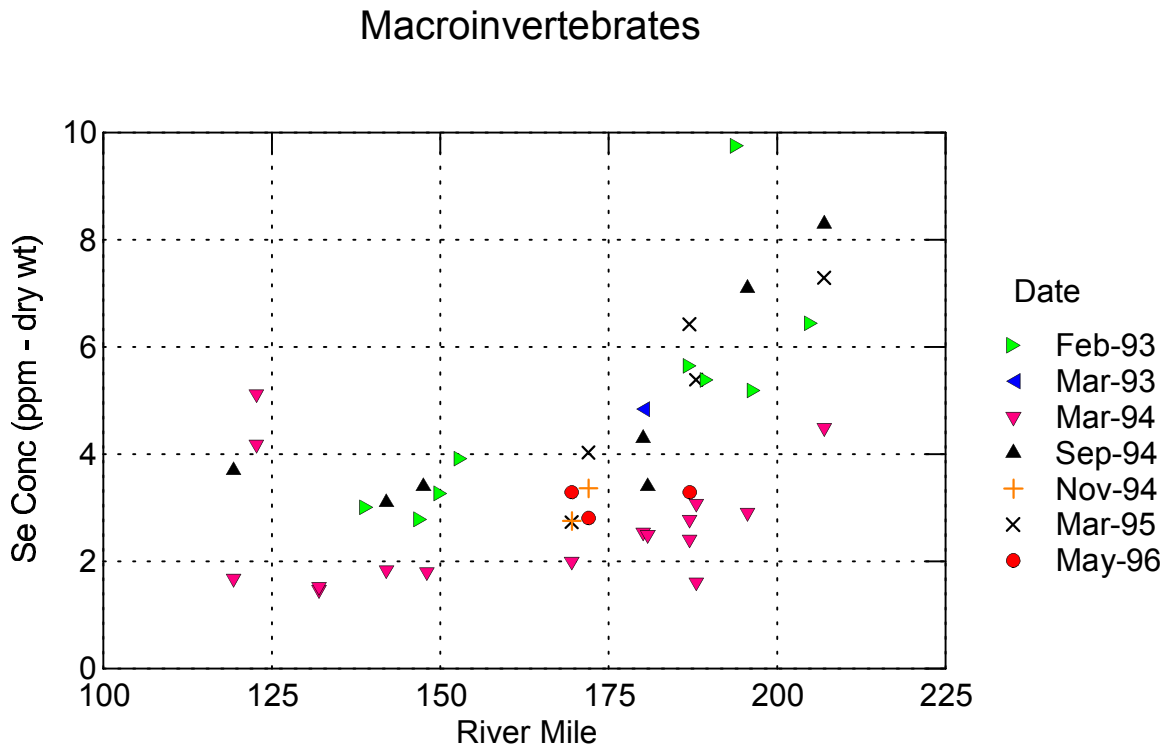

Figure 5.1. Selenium (Se) concentration in macroinvertebrates vs. distance downstream in the San Juan River.

Elevated PAH levels in channel catfish and common carp bile have been found in some locations of the San Juan River, but no clear pattern with flow has been established (Wilson et al. 1995). SPMD samples also did not indicate any significantly elevated levels, except in the Animas River sample at Farmington.

TOXICITY STUDIES

Hazards of As, Cu, Se, and Zn were assessed for Colorado pikeminnow and razorback sucker by Hamilton and Buhl (1996). Acute toxicity tests (96 hours) were completed on the larvae of the two species in water made up of experimental mixtures simulating various tributary waters along the San Juan River. Both the single salts, including arsenate, Cu, selenate, selenite, and Zn, and mixtures of all salts were tested. In general, razorback sucker is more sensitive to arsenate and the Se forms than Colorado pikeminnow (Table 5.2). For both species, the Gallegos Canyon mixture had synergistic toxicity and the Ojo Amarillo Canyon mixture had antagonistic toxicity. Applying a standard ratio of biological effect concentrations to environmental water concentrations of 100 to 1, only Cu had ratios less than the standard ratio. In addition to these experimental mixtures, Cu alone could adversely affect larval Colorado pikeminnow and razorback sucker in these reaches of the San Juan River, assuming the standard ratio is correct for Cu. Based on these results, some elements could be a concern for the native fishes in the San Juan River, but no relationship to flow could be determined.

Table 5.2. Acute toxicity (LC_{50}-96 hr) concentrations for several contaminants in the San Juan River.

	ACUTE TOXICITY (LC_{50}, 96H) IN PPB			
	Arsenic (As)	**Copper (Cu)**	**Selenium (Se)**	**Zinc (Zn)**
Colorado pikeminnow larvae	105,000	305	88,000	8,400
razorback sucker larvae	17,800	269	15,900	9,800

Chronic toxicity effects of Se on reproduction and survival of larval Colorado pikeminnow were studied by Hamilton in 1997 using dietary concentrations of 0, 5, and 10 ppm and water borne concentration of 0 and 5 ppb, but the results are not yet available. Preliminary results indicate that at the Se levels tested, which were above most values found in the San Juan River (Table 5.1, Figure 5.1), no difference in reproductive success could be found between the treatment and control groups.

FLOW/WATER QUALITY IMPLICATIONS

Based on the available water quality data from past sampling, there does not appear to be a significant change in trace element concentrations under low-flow conditions, as indicated in the individual columns of Table 5.1. Therefore, increased days with low flows should not cause a significant change in the trace element concentration.

The possible biological implication of a minimum flow recommendation at 500 cfs was analyzed in the following way:

> First, based on past observations, the effect of 500 cfs flows should not measurably change the overall trace element content of the water. Therefore, the organisms are not going to be exposed to different conditions.
>
> Second, for the area between Shiprock and Bluff where most of the endangered fishes have been found, the values found in Table 5.1 for As, Cu, Se, and Zn were examined under a 500-cfs flow condition. The extreme concentrations for these elements were 2, 10, 2, and 270 ppb, respectively. The toxicity of these elements at these concentrations was calculated as the ratios of the biological effect concentration to environmental water concentration. For Colorado pikeminnow the ratios were As = 52,500, Cu = 31, Se = 44,000, and Zn = 31. For razorback sucker the ratios were As = 8,900, Cu = 27, Se = 5,700, and Zn = 36. Assuming the ratios should exceed 100, then Cu and Zn are of concern for the larval stages. However, it seems unrealistic for the projected Cu concentrations to exceed the ratio > 100 criterion, because the Cu concentrations would have to be < 3 ppb, which is at or below the detection limit of commonly used analytical methods. The above ratios are unchanged over past flow conditions, so the concern is also expected to be unchanged for these four elements under the low-flow recommendation. It should be noted that only one value for Zn is of concern, and it may be the result of a sampling or analytical error, since this level is more than an order of magnitude higher than the mean and is a single incident.

Polycyclic aromatic hydrocarbon contamination is likely to be minimally affected by maintaining base flows at 500 cfs. To the extent that these flows are below historical levels, the low solubility of PAHs, the localized nature of potential effects, and the lack of indicated problems in the San Juan River would suggest that there will not be an increased risk at 500 cfs. A possible impact could occur if oil were spilled during low-flow conditions, which might provide less dilution. Given the modest change in base flows from historical conditions and the increase in summer base flows, the overall risk is minimal.

In summary, the available data do not suggest that contaminant levels and river discharge levels are related. Hence, contaminant issues were not used to develop flow recommendations. However, the contaminant load of future development projects should be carefully examined to determine the impact to contaminant concentrations in the river, especially those constituents that indicate a potential problem at present levels.